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JAPANESE ROCKET OBSERVATIONS AND EQUIPMENT

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JAPANESE ROCKET OBSERVATIONS AND EQUIPMENT

No Mura Tami Nari

(Engineering Research Institute, Tokyo University)

1. INTRODUCTION

Space research has been a major world interest ever since the Russians launched the first artificial satellite, Sputnik I, in 1957. /395

Subsequent sensational Russian successes and American all-out efforts have been widely reported, but there has been a tendency to overlook other important aspects of space research. The communications and meteorological satellites developed in the United States should greatly benefit mankind in the not too distant future. The veil of mystery surrounding space is gradually being removed as a result of observations above the atmosphere; a detailed picture is beginning to emerge. One of the outstanding successes of the IGY (1957-8) was the discovery of the Van Allen radiation belts. However, not only outer space is important, because it is found that there is a close relation between conditions in the upper atmosphere and ground-level weather; so many of the results are relevant to daily life.

Development of Japanese observation rockets started in 1955 and was centered at the Engineering Research Institute at Tokyo University. Various types of observation have been carried out since 1958 (Table 1). The countries participating in the IQSY (1964-5) have a program of various types of geophysical observations. (The IGY was a period of maximal solar activity.) Only 7 countries took part in the IGY rocket observations, but nearly 20 are expected for the IQSY. Japan is to use rockets of greatly improved performance. Author

2. JAPANESE ROCKET OBSERVATION SYSTEMS

2.1 Observation Rockets

Table 2 shows the types and capabilities. The rockets were initially designated by size (e.g., the Kappa series), but improvements in propellants provided much higher ceilings, after which the ceilings were used as the basis of classification. The 200 km ceiling type is

[redacted]

no.	date	time jst	time ut	rocket	experiment	atmos. struc.	ionos-phere	magele fields	radio waves	solar radiat.
S 1	June 24. 1958	1051	0151	K–6–3	TW–1	●				
S 2	June 30. 1958	1652	0752	K–6–4	TW–2	●				
S 3	Sept. 25. 1958	1155	0255	K–6–7	TW–3	⊙				
S 4	Sept. 25. 1958	1450	0550	K–6–8	RS–1					●
S 5	Sept. 26. 1958	1250	0350	K–6–9	TW–4	⊙				
S 6	Nov. 28. 1958	1205	0305	K–6–10	CR–1, P–1	⊙ P				
S 7	Nov. 29. 1958	1205	0305	K–6–11	RS–2					●
S 8	Nov. 30. 1958	1300	0400	K–6–12	CR–2, P–2	○ P				
S 9	Dec. 23. 1958	1203	0303	K–6–13	TW–5	○				
S10	Mar. 17. 1959	1035	0135	K–6–14	RS–3					●
S11	Mar. 18. 1959	1145	0245	K–6–15	TW–6	○				
S12	Mar. 19. 1959	1015	0115	K–6–16	RS–4					●
S13	Mar. 20. 1959	1150	0250	K–6–17	TW–7	○				
S14	July 17. 1960	1311	0411	K–8–2	ID–1		●			
S15	Sept. 17. 1960	1150	0250	K–6–18	TW–8	○				
S16	Sept. 22. 1960	1532	0632	K–8–3	ID–2, CR–3		○			
S17	Sept. 26. 1960	2025	1125	K–8–4	ID–3, CR–4		○			
S18	Sept. 29. 1960	1146	0246	K–6H–1	TW–9	○				
S19	Mar. 27. 1961	1308	0408	K–8–5	ID–4, AG–1		○ I. E. Te			
S20	Apr. 18. 1961	2127	1227	K–8–6	ID–5, AG–2		○ I. E. Te			
S21	June 18. 1961	1355*	0435	Σ–4–2 (rockoon)	CR–5, P–3	○ P				
S22	July 21. 1961	1142	0242	K–8–7	ID–6, TW–10	○	○ I. E. Te			
S23	Oct. 24. 1961	1259	0359	K–8–8	ID–7		○ I. E. Te			
S24	Oct. 30. 1961	2013	1113	K–8–9	ID–8, AG–3		● I. E. Te			
S25	Dec. 26. 1961	1405	0505	K–9L–2	ID–9		⊙ I. Te			
S26	May 24. 1962	1950	1050	K–8–10	ID–10, GA–1		● I. E. Te	● GA		
S27	Nov. 25. 1962	1104	0204	K–9M–1	ID–11		● I. E. Te			
S28	Dec. 18. 1962	1403	0503	K–8–11	CR–6, GA–2 RN–1			○	○	

[Table 1 Continued on Next Page]

Table 1.

List of firings of sounding rockets

[Table 1 Continued]

airglow	cosmic rays	miscel.	firing place	geographic coordinates	altitude km	apex position (direction distance km)	institution in charge	perfomance and remarks
			MICHIKAWA (AKITA)	39° 34′ 12″N 140° 03′ 35″E	CO 20		K. U. O. C. U.	
			〃	〃	CO 40	275. 2° 10. 0	K. U. O. C. U.	
			〃	〃	43. 5		K. U. O. C. U.	
			〃	〃	UNCERTAIN		T. A. O.	
			〃	〃	52. 9	244. 0° 35. 0	K. U. O. C. U.	
	⦿		〃	〃	35. 6	270. 2° 40. 0	I. P. C. R. I. I. S.	
			〃	〃	41. 0	268. 2° 27. 5	T. A. O.	
	○		〃	〃	48. 2	265. 2° 43. 0	I. P. C. R. I. I. S.	
			〃	〃	59. 0	268. 2° 37. 0	K. U. O. C. U.	
			〃	〃	54. 0	265. 8° 27. 5	T. A. O.	
			〃	〃	48. 5	278. 4° 26. 0	K. U. O. C. U.	
			〃	〃	41. 3	258. 3° 34. 9	T. A. O.	
			〃	〃	48. 6	289. 4° 32. 0	K. U. O. C. U.	
			〃	〃	186. 0	273. 6° 175. 0	R. R. L. E. C. L.	
			〃	〃	46. 0	284. 5° 46. 0	K. U. O. C. U.	
	○		〃	〃	197. 5	269. 5° 103. 0	R. R. L. E. C. L. I. P. C. R.	
	○		〃	〃	183. 0	270. 0° 135. 0	R. R. L. E. C. L. I. P. C. R.	
			〃	〃	68. 3	284. 0° 45. 0	K. U. O. C. U.	
●			〃	〃	169. 2	270. 9° 109. 9	R. R. L. E. C. L. T. A. O.	
●			〃	〃	144. 2	271. 6° 145. 1	R. R. L. E. C. L. T. A. O.	
	Q		OBUCHI (AOMORI)	40° 42′N 141° 44′E	105. 0		I. P. C. R. I. I. S.	
			MICHIKAWA (AKITA)	39° 34′ 12″N 140° 03′ 35″E	159. 0	271. 3° 139. 8	R. R. L. E. C. L. K. U. O. C. U.	
			〃	〃	198. 0	285. 9° 143. 9	R. R. L. E. C. L.	
○			〃	〃	174. 5	271. 7° 104. 3	R. R. L. E. C. L. T. A. O.	
			〃	〃	347. 6	284. 3° 331. 0	R. R. L. E. C. L.	
			〃	〃	0	0	R. R. L. T. U.	
			UCHINOURA (KAGOSHIMA)	31° 15′ 00″N 131° 04′ 45″E	55. 1	125. 5° 27. 3	R. R. L.	
	○				202. 1	149. 3° 119. 5	I. P. C. R. T. U. K. U. U. T.	

Name	Type	Diameters, mm	All-up weight, kg	Overall length, mm	Payload, kg	Height reached (km) for launching angle of 80°	No. of firings
Kappa 6	2 stages	150 + 245	260	6000	12	60	15
Kappa 6H	2 stages	150 + 245	330	7000	12	80	1
Kappa 8	2 stages	245 + 420	1500	11000	50	200	12
Kappa 9L	3 stages	150 + 245 + 420	1500	12500	15	350	2
Kappa 8L	2 stages	150 + 245	350	7000	15	200	1
Kappa 9M	2 stages	245 + 420	1500	11000	50	400	1
Lambda 2	2 stages	420 + 735	6000	16500	100-150	600-800	July 1963

Table 2.

Parameters of Japanese rockets

called Mark 8; 350-1000 km, Mark 9. Kappa 8L was an improved version of Kappa 6H, and Kappa 9M is an improved version of Kappa 8. The Kappa series ends with Mark 9; the new 735-mm diameter rockets form the Lambda series. A Lambda 2 two-stage rocket should be fired this summer, and a Lambda 3 during the year (Lambda 3 is a three-stage rocket, with a 245-mm third stage mounted on a Lambda 2). Lambda 3 should have a ceiling of 1500 km for a payload of 50 kg.

Development of the Mu series (diameter 1.4 m) should begin within the year. This series is expected to be ready in 1966 and should attain orbit velocities.

The launch site was initially on the Michikawa coast (Akita prefecture), but the Sea of Japan is not large enough for the longer-range rockets, so in 1962 it was decided to set up the Space Research Station of Tokyo University on the east coast of Osumi peninsula (Kagoshima prefecture) at Uchinoura. The station came into part-time use that summer, and all future launchings will be made from it.

Many geophysical phenomena are closely related to terrestrial magnetism. The Earth's magnetic poles do not coincide with its geographic ones. Japan lies in low magnetic latitudes, and the Kagoshima station is at the lowest magnetic latitude of any rocket station. Further, it is the only experimental rocket station in the northern hemisphere anywhere near longitude 130°, so it should provide data otherwise unavailable.

2.2 Telemetry and Radar Equipment

The data are transmitted to the ground and recorded there in most /396
cases. The effects of height are usually significant, so the track must be determined. Telemetry is used for the former purpose and several radar installations for the second.

2.2.1 Telemetry Equipment. The FM-FM method is used (10 chan- /397
nels) at 225 Mc at present; the larger rockets should provide a payload capable of handling 40 channels on four frequencies in the 298 Mc band. Figure 1 shows a block diagram of the telemetry equipment.

The data are converted to voltages in the range 0-5 v, which /398
are used to modulate the frequencies of subcarrier oscillators. The frequency excursion is ± 7.5 %. The subcarriers modulate the high-frequency carrier, which is transmitted to the ground. Double frequency modulation (FM-FM) is used. The signal received at the ground station is detected in the receiver, and the subcarriers are isolated by filters. The signal discriminator gives an output proportional to the frequency deviation of the subcarrier, and this is amplified and passed to a pen recorder or oscilloscope.

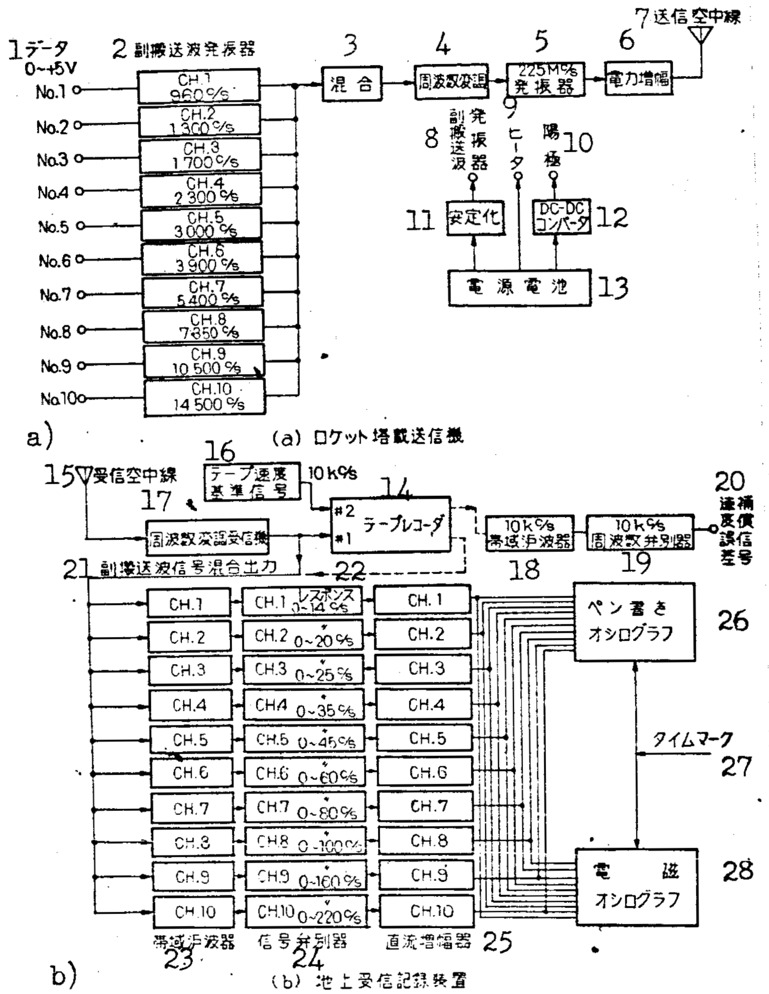

Fig. 1.

Telemetry system: a) transmitter in rocket; b) ground station system. 1) Input; 2) subcarrier oscillators; 3) mixer; 4) frequency modulator; 5) 225 Mc oscillator; 6) power amplifier; 7) transmitting antenna; 8) to subcarrier oscillators; 9) to heaters; 10) to plates; 11) stabilizer; 12) dc-dc converter; 13) batteries; 14) tape recorder; 15) receiving antenna; 16) tape speed standardizing signal; 17) FM receiver; 18) 10 kc filter; 19) 10 kc frequency discriminator; 20) tape speed error compensating signal; 21) mixed subcarriers; 22) passband; 23) filters; 24) signal discriminators; 25) dc amplifiers; 26) pen oscillograph; 27) time marks; 28) oscilloscope.

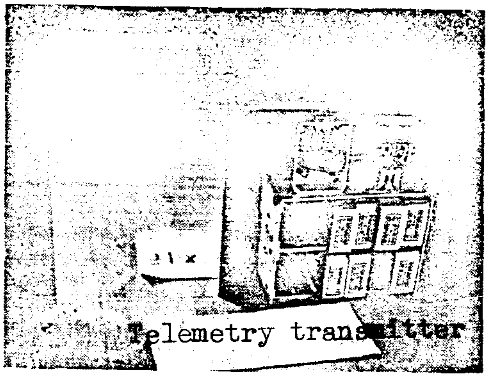

Fig. 2

Telemetry transmitter.

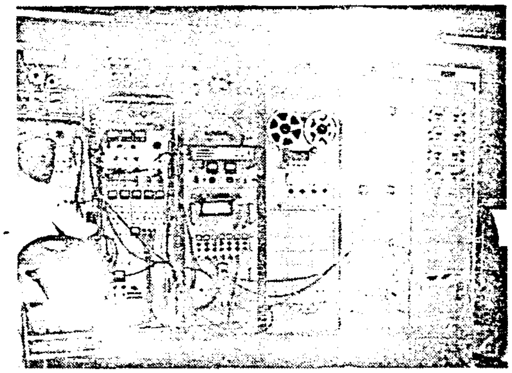

Fig. 3

Telemetry receiving and recording equipment.

The output from the receiver (the mixture of subcarriers) is recorded on tape; the data are then not lost and can be checked if the recording system is suspected of faults. Further, any number of copies can be generated. A difficulty is that the tape-speed varies (wow and flutter occur), which may introduce frequency errors in playback. This is overcome by recording a standard fixed-frequency signal (10 kc), which provides a means of correcting for tape speed variation.

The equipment in the rocket must be small and light. The oscillators are all transistorized, but the transmitting stage at present employs vacuum tubes. Miniaturization is favored by low signal output; the present power is about 1 w. Figures 2 and 3 give general views of the transmitting and receiving systems. /399

Reception over long distances with low power demands an antenna of high gain and a low-noise receiver.

A parabolic reflector (diameter 18 m) is at present in use at Kagoshima, which is being equipped with an automatic tracking system; this should provide reception out to 10 000 km or more when completed. /400

2.2.2 Automatic Tracking System. The line-of-sight distance is given by the time for a pulse sent from the ground to return from the rocket; the altitude is deduced from the elevation of the antenna, which automatically follows the rocket. The position is evaluated from these parameters in the automatic tracking system (Fig. 4). The

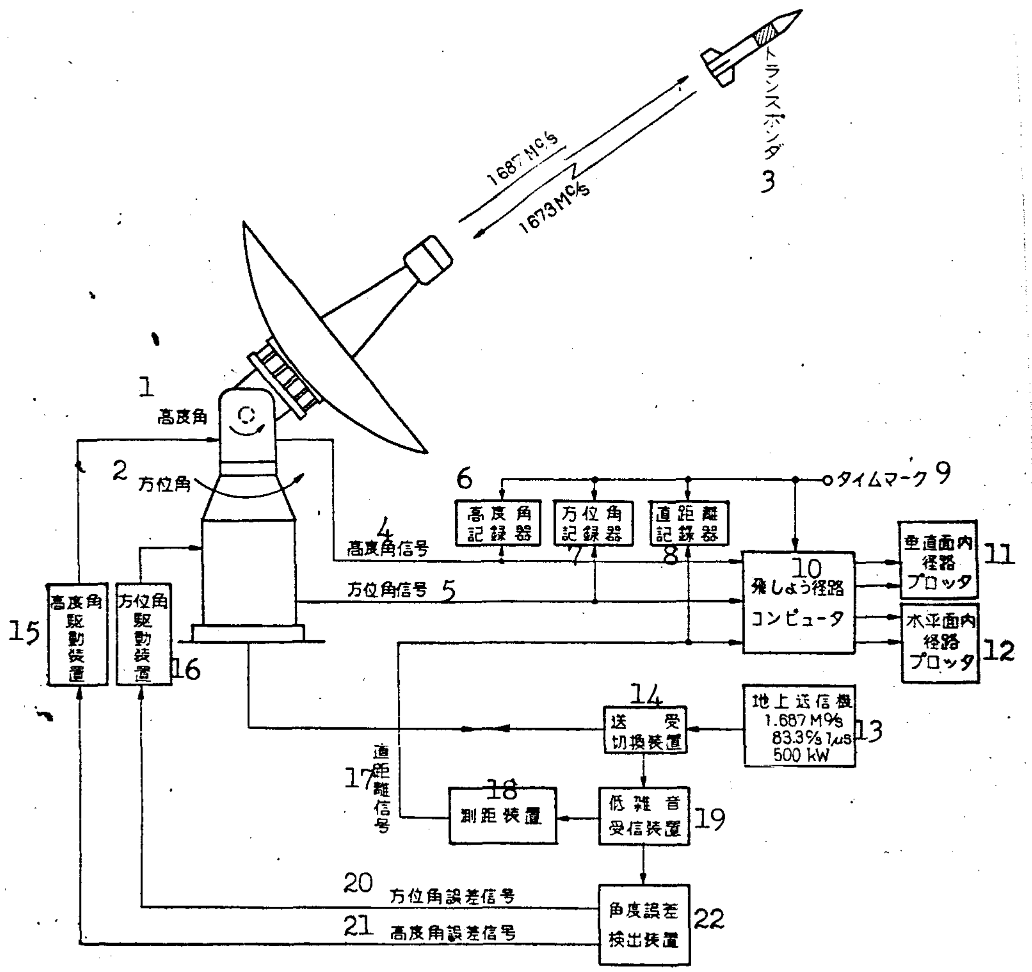

Fig. 4.
Automatic tracking radar system.

1) Elevation; 2) azimuth; 3) transponder; 4) elevation signal; 5) azimuth signal; 6) elevation recorder; 7) azimuth recorder; 8) line-of- sight distance; 9) time marks; 10) track computer; 11) vertical coordinate plotter; 12) horizontal coordinate plotter; 13) ground transmitter; 14) send-receive switch; 15) elevation control gear; 16) azimuth control gear; 17) distance signal; 18) distance computer; 19) low-noise receiver; 20) azimuth error signal; 21) elevation error signal; 22) angle error detector.

rocket carries a combined receiver and transmitter (transponder); a pulse from the ground elicits a reply pulse, which is transmitted back to the surface. This means that it can receive a weak signal and send back a return signal of sufficient power. The transponder system is known as a two-stage radar system; passive reflection from the rocket is known as a one-stage system. A small rocket has only a small reflecting area, so a single-stage system requires high-power radar equipment; a two-stage system is more economical, for low-power equipment is used.

Figure 5 shows the automatic tracking antenna (parabolic reflector, 4 m). The operating frequency is 1680 Mc; single-stage radar can be used, although two-stage is normally employed. The pulse power is 500 kw at a pulse repetition rate of 83.3 cps.

3. IN-FLIGHT TEST EQUIPMENT

In-flight tests are employed to establish whether new rockets provide their design performance. Table 3 shows the measurements that /401
are made.

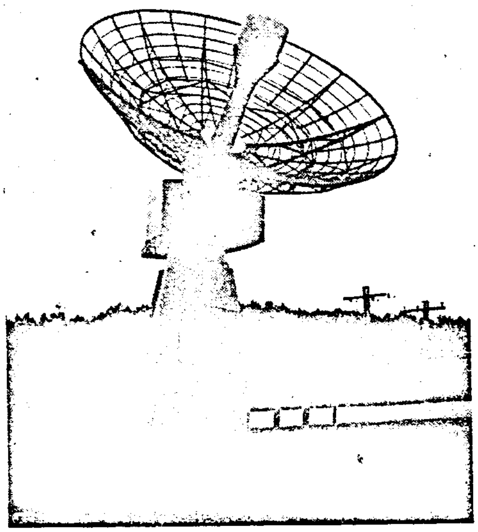

Fig. 5

4 m automatic tracking radar antenna.

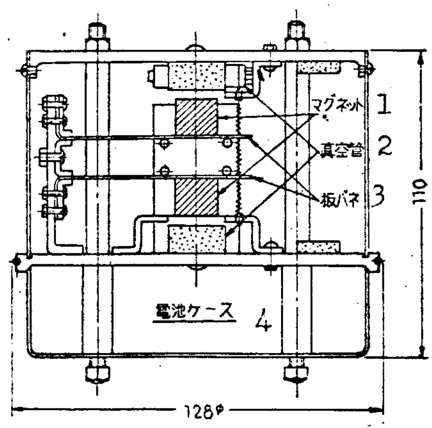

Fig. 6.

Miniature-tube accelerometer. 1) Magnet; 2) tube; 3) flat spring; 4) battery case.

Item	Principle	Conversion method	Range
Vertical acceleration	Spring, mass displacement	MV	0–50g 100c/s 0–25g 65c/s 0–11g 40c/s
Lateral acceleration	Ditto	Ditto	±6g 65c/s
		Potentiometer	±3g 10c/s
Vibration	Ba titanate transducer	ac amplifier	±5g 50–800c/s
Temperature	Pt resistance	Unbalanced ac bridge, output amplification, and rectification	350 °C
	Thermistor	Unbalanced dc bridge	350 °C
	Thermocouple	dc amplification	800 °C
Strain	Resistance change in wire strain gauge	Unbalanced ac bridge, output amplification, phase-sensitive detection	±6kg/mm^2
Internal pressure	Semiconductor strain gauge	Ditto	

Table 3.

Measurements by In-Flight Test Instruments and Methods of Determination.

Figure 6 shows the MV accelerometer, whose main features are flat spring and localized load (permanent magnet). The plate current

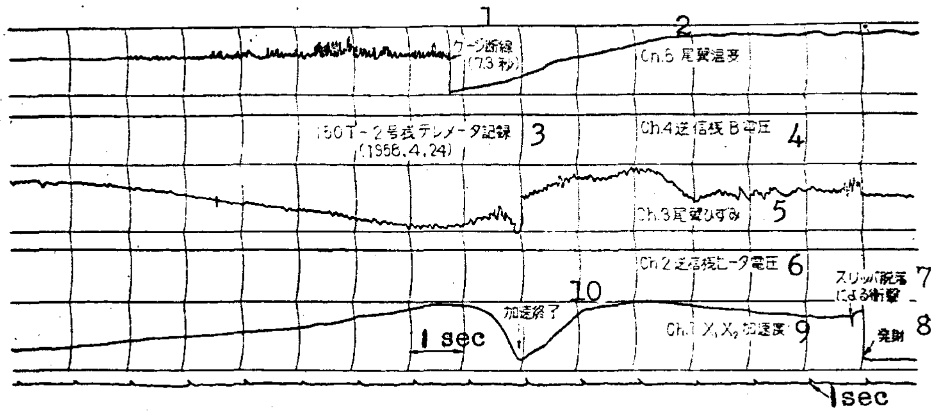

Fig. 7.

Accelerometer record.

1) Gauge cut-in (7.3 sec); 2) channel 5, tail temperature; 3) telemetry record 150T-2 (4/24/1958); 4) channel 4, transmitter B voltage; 5) channel 3, tail fin strain; 6) channel 2, transmitter heater voltage; 7) shock caused by release; 8) firing; 9) channel 1, X_1 and X_2 acceleration; 10) end of acceleration.

of a subminiature vacuum tube is affected by the magnetic field, so displacement of the magnet is translated into dc voltage variation. Balance is effected at zero, and acceleration and deceleration are transmitted in a single channel. Figure 7 shows a type telemetry recording.

Temperature sensors are located at the nose, amidships, at the tail, and on the payload capsule; these are selected at second intervals by a switch, to provide transmission in one channel.

These measurements provide determination of engine performance and stability as well as of tail loading and heating; these should provide the basis for improved designs.

4. OBSERVATIONS AND METHODS

The observations to be made have been discussed by the organizations shown in Fig. 8; Table 1 lists the main types of observation, which are as follows: 1) atmospheric structure, 2) ionosphere, 3) electric and magnetic fields, 4) radio phenomena, 5) solar radiation, 6) airglow, and 7) cosmic rays.

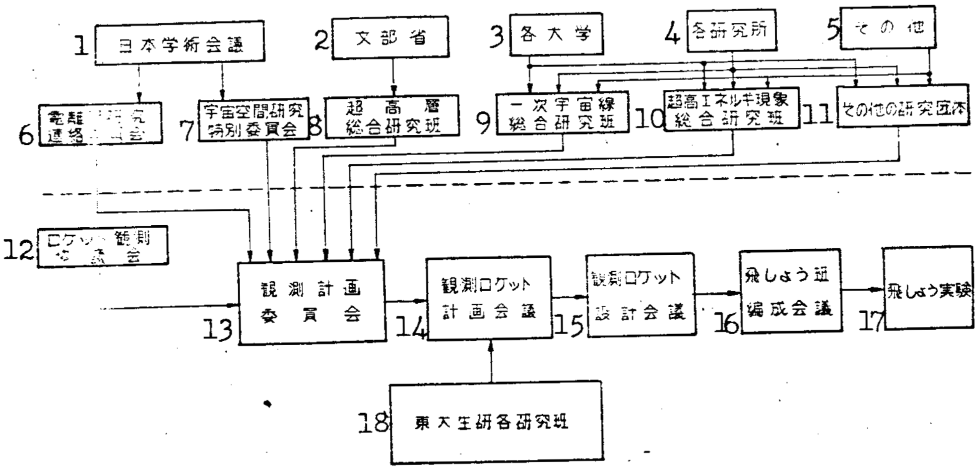

Fig. 8.
Rocket research organization (part).
1) Japanese Science Council; 2) Dept. of Education; 3) Universities; 4) Research Institutes; 5) others; 6) Ionosphere Liaison Committee; 7) Space Research Committee; 8) Upper Atmosphere Joint Committee; 9) Primary Cosmic Rays Joint Committee; 10) High-Energy Phenomena Joint Committee; 11) other research groups; 12) Rocket Research Council; 13) Observation Planning Committee; 14) Observation Rocket Design Council; 15) Observation Rocket Development Group; 16) Flight Testing Committee; 17) Flight Group; 18) Tokyo University Engineering Research Groups.

These have been selected mainly on the following basis: 1) the observation should, as far as possible, be original; 2) the method should be original; and 3) advantage should be taken of Japan's geographic position.

4.1 ATMOSPHERIC STRUCTURE

Temperature, pressure, and wind speed are all important. The /402 first and last are the most important in Japan, for the middle of the four seasons. In particular, data for the spring equinox provide valuable evidence that can be obtained only in Japan.

a) at front (6 charges) b) rear side (8 charges)

Fig. 9
Mounting the charges.

The grenade method has been used up till now in Japan. The multiple charges are arranged to detonate at nearly equal height intervals starting from 20 km. The sound waves (minute changes in air pressure) are received by hotwire microphones at ground level. The variation in the speed is found from the times of arrival of successive waves, and the air temperature is calculated from this. The direction of the source of the waves can be deduced, since the microphones are placed some distance apart; this gives the wind speed and direction. This supplements the existing radiosonde data (up to 20 km) by values for the upper atmosphere.

Charges of 0.3-1 kg are used, the height of detonation being the controlling factor. These are fitted at the front or edge of the tail, as shown in Fig. 9. Figure 10 shows a microphone pit, which is covered by canvas to eliminate interference from surface winds. Figure 11 shows some results.

The method is inapplicable above 80 km, because the attenuation becomes so great; the sodium method was therefore introduced in May of this year. A sodium cartridge is released at a specified height, and the sodium is vaporized; the solar radiation causes the vapor cloud to emit light. The cloud is photographed from two or more places on the ground, from which the wind speed and direction can be deduced. This involves firing the rocket during the brief period when it is dark at ground level /403 but the upper atmosphere is sunlit (dusk or dawn), when there is no moon. Further, the sky must be clear. These numerous limitations on the time form a major drawback.

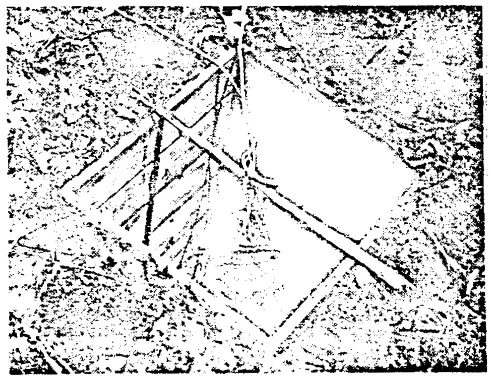

Fig. 10
Microphone

The chaff method may also be used; here dipoles are released and their motion is followed by radar. A method (Russian) of measuring the air temperature is to transmit ultrasonic waves from a source to a receiver, the transit time giving the speed of sound and hence the air temperature.

4.2 IONOSPHERE

Measurements are made of the ion density, electron density, and electron temperature in order to establish the structure of the ionospheric layers. Radio observations from the ground were formerly used, but the evidence from these is very indirect. Rocket-borne instruments provide direct and detailed information on the structure.

a) Langmuir probe. Measurements are made of the current flowing between the probe and the body of the rocket; the current produced by a negative voltage is the ion current, so the ion density may be found. The electron temperature and density can be deduced from the response to positive potentials.

The probe is a sphere 20 mm in diameter (Fig. 12); the grid structure is used to minimize error from photoelectron emission. Gold-plated Mo wire (0.3 mm) is used. The hollow structure makes it light. Its performance at night is undoubtedly ideal. This probe is an entirely Japanese development; it is the first to provide reliable daytime ion density measurement.

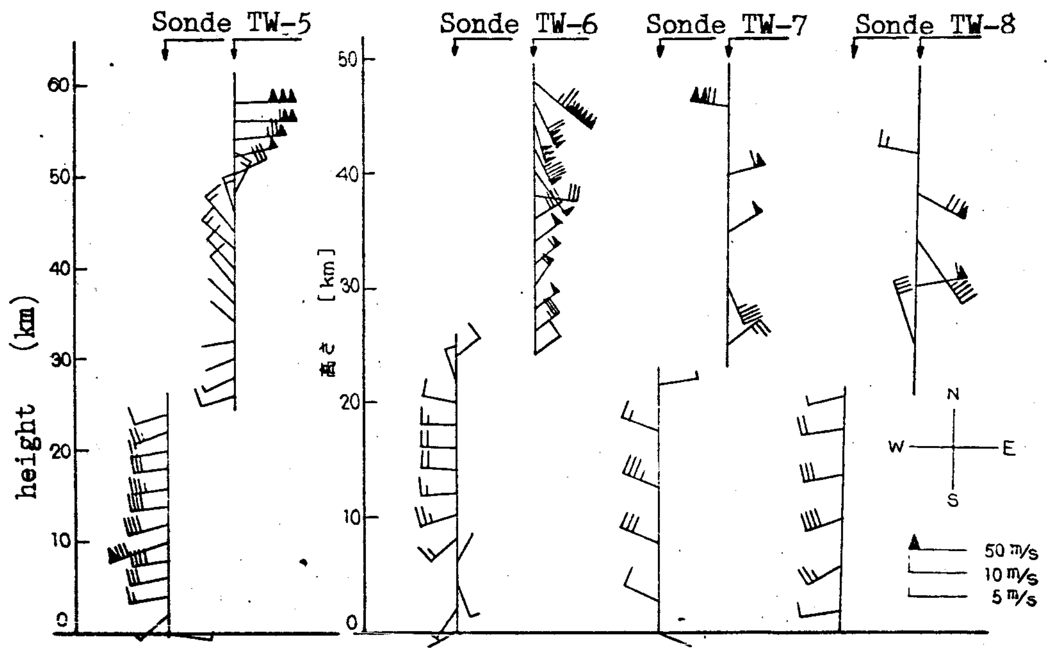

Fig. 11
Wind-speed observations.

b) Resonance probe. The high-frequency voltage is accompanied by dc bias; Fig. 13 shows the output as a function of frequency, the resonance frequency f_e being

$$f_e = \sqrt{\frac{e^2 N_e}{\pi m}} \tag{1}$$

in which e and m are the charge and mass of an electron respectively. The electron density N_e is thereby found. The low-frequency output voltage is

$$\frac{eV_a}{KT_e} = \log I_o\left(\frac{ea}{KT_e}\right) \qquad (2)$$

in which I_0 is a Bessel function, a is the amplitude of the hf voltage, and K is Boltzmann's constant. The electron temperature T_e is thereby found.

The Langmuir probe can also give N_e and T_e, but really good values are hard to obtain; the resonance probe gives highly reliable results, for the density is measured as a frequency.

The resonance probe is also entirely Japanese in conception and development; it is highly regarded all over the world. By request of NASA, it was used in connection with direct measurements on the ionosphere. In May last year it was used in a Nike-Cajun rocket, and it is to be used in conjunction with other apparatus in an Aerobee-Hi. /404

The probe is rather delicate. At first it was housed in the front section of the rocket. The front section breaks away at a height of 60 km and the probe is exposed. Figure 14 shows a multipurpose five-part probe still in its folded state at the moment of opening of the nose cone.

4.3 Cosmic Rays

So far, the intensity has been measured only as a function of height; but the development of an attitude-measuring instrument that senses the Earth's magnetic field (see later) enabled us in December of last year to record the directional distribution, in which three geiger counters were used in coincidence. Preparations are also being made to measure the energy (pulse-height) distribution.

Altitudes so far attained are slightly below 200 km, so no novel results are to be expected. The middle Van Allen radiation belt lies at heights between 1500 and 3000 km over Japan, so our rockets should give novel results when they attain this height. A third radiation belt below this has been predicted for the area between Japan and Southeast Asia, which, if confirmed, would be very important.

4.4 Airglow

Particulate radiation and ultraviolet light from the Sun excite

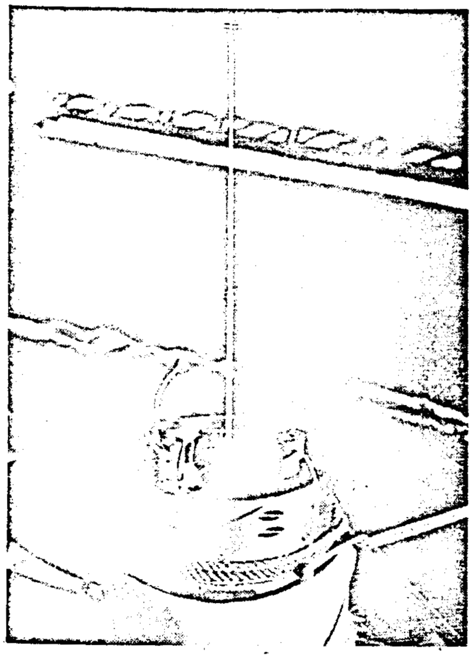

Fig. 12.
Net probe.

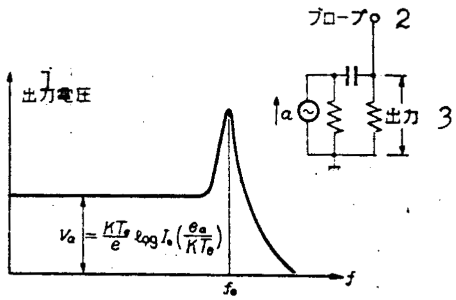

Fig. 13
Resonance probe method.
1) Output voltage;
2) probe
3) Output

the components of the upper atmosphere and light is emitted; different wavelengths come from various layers. It is difficult to determine the heights of these layers from the ground, but direct measurements can be made from rockets.

The light includes the 5577 Å (green) and 6300 Å (red) lines of the oxygen atom, the sodium D lines (yellow), and the near-infrared emission of OH. Measurements have been made in the United States of the heights at which the 5577 and sodium D lines are emitted; no data are available for the near infrared.

The light from these layers is received by a periscope (Fig. 15), which is released on both sides when the rocket is at a height of about 60 km. Interference filters separate the wavelengths, and photocells measure the intensities. The variations in the latter are used to deduce the layer heights. The results so far obtained (Fig. 16) confirm previous evidence.

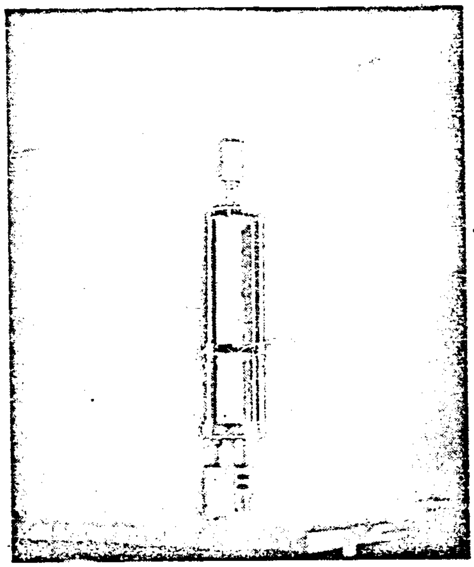

Fig. 14.
Release of probe when nose opens.

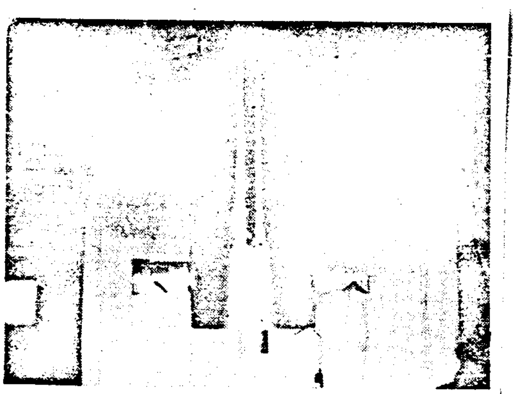

Fig. 15
Airglow observation instruments.

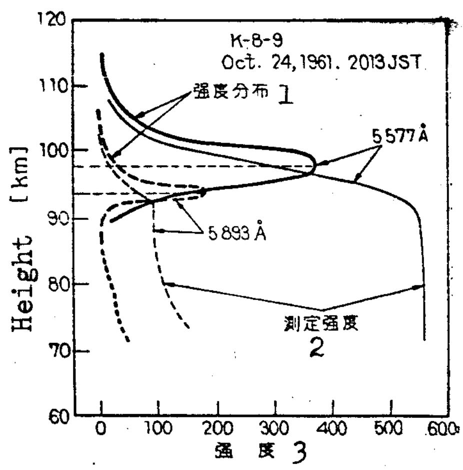

Fig. 16.
Determination of height of airglow layers. 1) Gradient of intensity; 2) total intensity; 3) intensity

4.5 Terrestrial Magnetism (Attitude-Sensing Device)

Terrestrial magnetism is closely related to many geophysical phenomena. The field in the ionosphere shows minor deviations from that to be expected from the dipole theory, so magnetism related to the structure of the layers is an important topic. /405

A precise method of measuring the Earth's field by means of proton resonance has been worked out and is now about to be utilized. There are technical difficulties in making the rocket of nonmagnetic material, so future developments are involved in a method of recording the attitude by reference to the Earth's field. The magnetometer is a thin permalloy rod, to which low-frequency magnetic fields are applied. When the axis

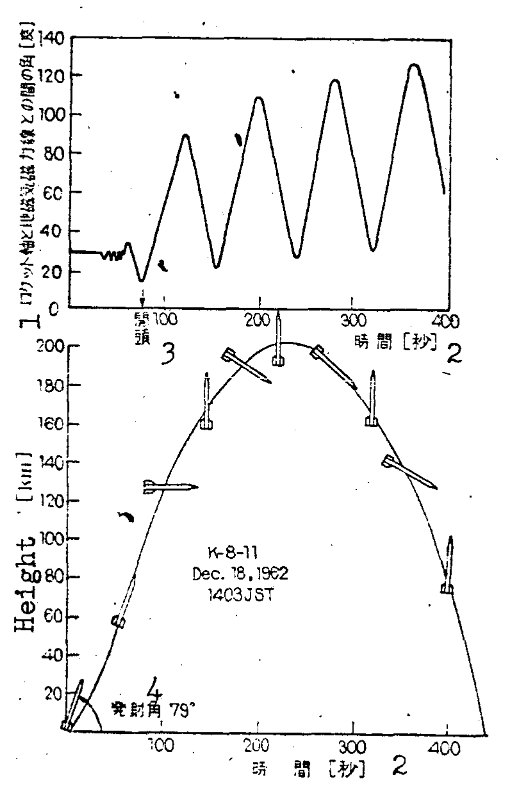

Fig. 17.
Attitude of rocket in flight.
1) Angle between axis of rocket and direction of field (deg); 2) time (sec); 3) opening of nose; 4) firing angle 79°

lies obliquely to the Earth's field, the field becomes unbalanced and harmonics are generated. One of these detectors is used for each axis, which gives the components and hence the attitude. The attitude is very important for the interpretation of other readings, and we think that such an instrument will become standard equipment in the future.

Figure 17 shows typical results. The rocket shows a tumbling motion in the upper atmosphere, because there is nothing to stabilize it, as has already been reported; but the opening of the nose cone sets up a persistent tumbling.

4.6 Solar Flares

A spectrograph was included in the payload in four firings of Kappa 6, in order to record the ultraviolet spectrum below 2900 Å, which is prevented from reaching the ground by absorption in the atmosphere. The film is recovered from the sea. The watertight nose cone, which houses the spectrograph, separates from the rocket at a height of about 40 km and falls on a parachute. A float is inflated when the cone strikes the sea, and the cone is recovered by boat or helicopter. Recovery was not achieved in two of the four firings.

There are many difficulties in recovering components in this way. Recovery from the sea was essential to the Mercury project, which made it not so convenient as the Russian method. Japanese facilities for recovery are limited, so recovery from large distances represents great difficulties.

Transmission by television link has been proposed to overcome this difficulty. A sun follower is essential for observations of the Sun; this keeps the instrument facing the Sun.

A coronagraph is carried, and corona observations can now be made which formerly could only be made at total eclipse. These are all the developments up to now.

4.7 Radio Phenomena

Electromagnetic waves are generated above the atmosphere. The distributions of these in frequency and direction are important in relation to their origins. Some information on the structure of the ionosphere can also be obtained from the propagation characteristics.

A receiver in the rocket measures the signal strength at a rather low frequency (a few kc), which requires a large antenna. The first tests were done in December of last year with an antenna 5 m long that was unreeled when the nose cone opened. Two experiments in May this year were done with a 3 m antenna in three sections extended by compressed air.

No country has carried out observations in this field for any length of time, but even the first phase yielded more detail than was expected, so great hopes are held for the future.

5. CONCLUSIONS

In spite of restricted space it has been possible to mention briefly the objectives and methods of observation in Japanese rocket research. I fear that many important points have had to be omitted, but I hope I have made the present situation clear. Cooperation between many different disciplines is essential in rocket research, and I earnestly hope that cooperation will be forthcoming from every side.

FARADAY TRANSLATIONS
15 PARK ROW
NEW YORK 38, N. Y.